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SOUND TRANSMISSION IN THE 48-INCH WATER TUNNEL FOR A RANGE OF TOTAL AIR CONTENT, PRESSURE, AND VELOCITY,

D. E. Thompson

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Technical Memorandum.
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It is well known that the presence of small bubbles in water can cause attenuation of transmitted sound. An experiment was performed in the 48-inch diameter water tunnel test section to determine the effects of total air content, test section pressure, and velocity on the transmission of sound. It was shown that there is negligible attenuation of sound for typical ranges of the variables considered.

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Internal Memorandum

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M. L. Billet, F. S. Archibald, ARL Files (4), Water Tunnel Files

From: D. E. Thompson

Subject: Sound Transmission in the 48-inch Water Tunnel for a Range of Total Air Content, Pressure, and Velocity

References: See Page 6

Abstract: It is well known that the presence of small bubbles in water can cause attenuation of transmitted sound. An experiment was performed in the 48-inch diameter water tunnel test section to determine the effects of total air content, test section pressure, and velocity on the transmission of sound. It was shown that there is negligible attenuation of sound for typical ranges of the variables considered.

Acknowledgement: This work was performed under contract with the Naval Sea Systems Command, Code 0371.

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Introduction

Hydrodynamic noise sources have become the subject of increasing experimentation in the various water tunnels at The Applied Research Laboratory in recent years. It is expected that such work will continue at at least the same level of effort in the future. The present memorandum considers determining an important acoustic characteristic of the 48-inch water tunnel.

It is well known that the presence of small bubbles in water will cause attenuation of sound transmitted through it. The amount of attenuation and the frequency at which attenuation occurs is a function of the bubble size distribution, static pressure, density of water, etc., References 1 and 2.

In any water tunnel there is a certain amount and size distribution of free air in the water. If the amount and distribution of free air are known, then techniques exist for estimating the acoustic attenuation due to free air, Reference 2. At the present time, no accurate technique for determining the free air exists at the Fluids Engineering Department. The attenuation of sound has, therefore, been measured directly under typical operating conditions in the 48-inch diameter water tunnel. The effects of total air content, and test section velocity and pressure on the sound transmitted in the test section were measured. The ranges of the considered variables are typical of those encountered in tests involving the measurement of hydrodynamic noise.

Test Facility and Apparatus

Tests were conducted in the test section of the 48-inch diameter water tunnel. The test section is 14 feet long. There are three plexiglass windows on each side of the test section. A water filled tank, external to the test section, spans its length on one side of the test section. A reflecting hydrophone is suspended in the tank and serves as a receiving hydrophone.

A piston hydrophone was mounted in the center of one plexiglass window in the test section, opposite the receiver and served as the sound source. Figure 1 shows this arrangement. For the tests conducted, the sound source and receiver were positioned directly across from each other.

The flow velocity in the test section can be varied from 0 to approximately 60 fps. The pressure in the test section can be varied from approximately 6 to 40 psia. The total gas content can be reduced to approximately 2 ppm.

Data Acquisition and Reduction

A block diagram of the data acquisition and reduction system is shown in Figure 2. The received hydrophone signal was amplified and then transmitted to the real time analyzer. The spectrum of the received signal was obtained for the frequency range 0 to 50 kHz which is the upper limit of the Spectral Dynamics 301-C analyzer. The bandwidth for this frequency range is 150 Hz.

Description of the Tests

The piston hydrophone sound source was excited with white noise by a General Radio model 1390B white noise generator for each test conducted.

Measurements of the spectra of the transmitted sound were made for various flow conditions. The test section velocities considered were 0, 20,30, 40, and 50 fps. For each of these velocities, the test section pressures considered were 18.2, 9.1, and 6.6 psia. For each combination of velocity and pressure, the total air contents considered were 3.2, and 9.1 ppm on a mole basis. This is a sufficient range of total air contents and pressures to span the conditions at which tests are normally conducted at ARL.

Results and Conclusions

The results of these measurements are shown in Figure 3. This figure shows the spread of the spectra of the sound transmitted through the test section for all test conditions considered. The maximum spread is 2.8 dB at the lower frequencies. This amount of deviation can be ascribed to measurement errors alone and not to any effects of total air content, pressure, or velocity on the transmitted sound. The conclusion is that in the frequency range 0 to 50 kHz, for the range of variables considered insignificant attenuation of sound in the ARL/PSU 48-inch water tunnel.

Future Experiments

Two experiments designed to extend and/or amplify the current results are planned.

The first experiment will employ a laser nuclei counter to measure the bubble size distribution which exists in the water tunnel test section under typical test conditions. The development of the necessary instrumentation and techniques for a useful system are currently underway.

The second experiment will employ a system of high frequency hydrophones, 50 kHz to 300 kHz, to determine the sound attenuation, in that frequency range, in a manner similar to that described in the present memorandum. Mounting systems for the high frequency hydrophones are being designed at the present time.

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2. Brockett, T., "Computational Method for Determination of Bubble Distributions in Liquids," DTNSRDC Report No. 2798, April 1969.

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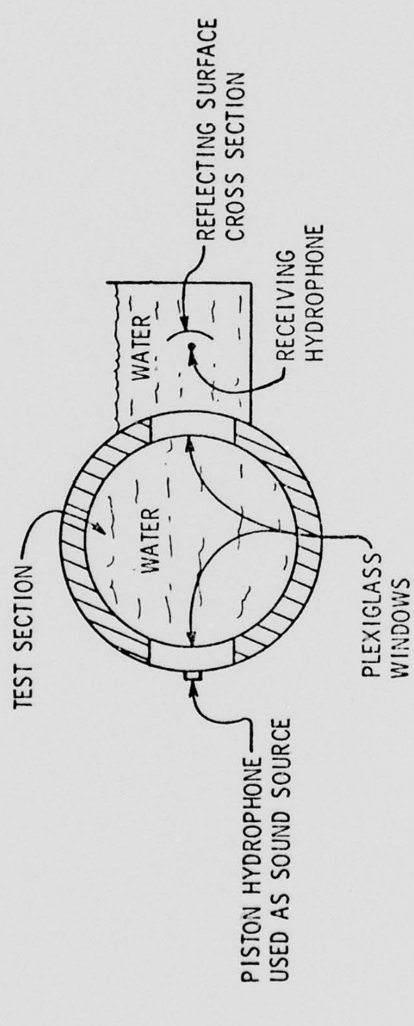

Figure No. 1 Schematic of Test Facility and Hydrophones

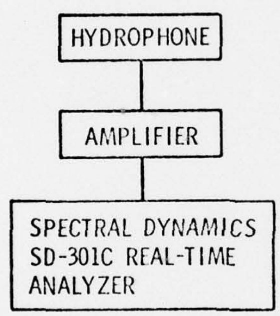

Figure No. 2 Block Diagram of Data Acquisition and Analysis System

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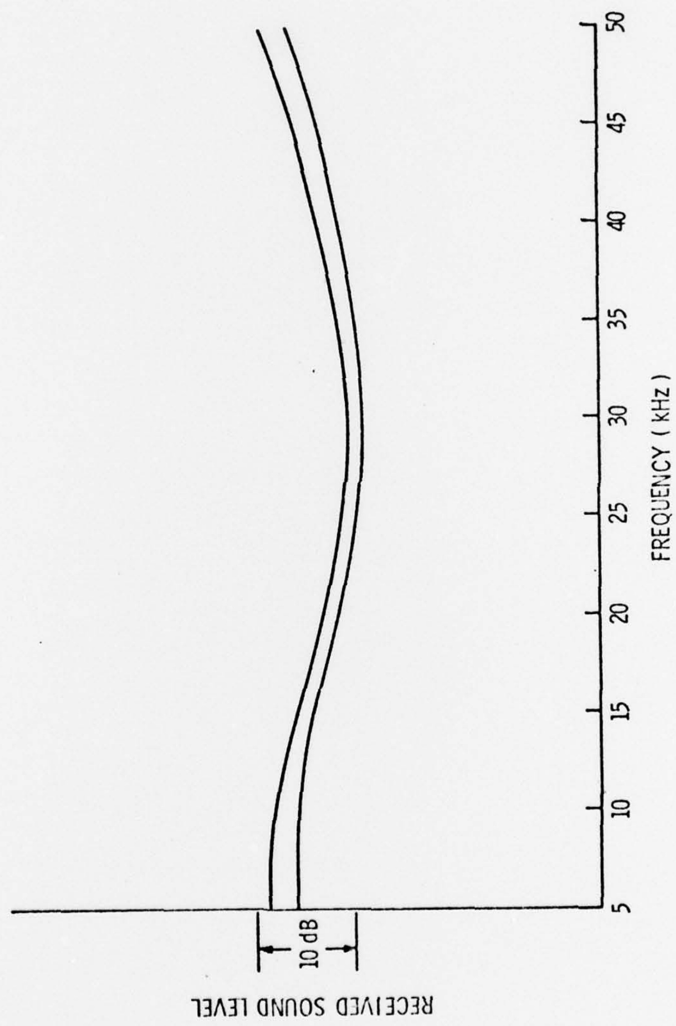

Figure No. 3 Spread of the Received Sound Level versus Frequency

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